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THE TOTAL LIGHT OF THE STARS.

By Sidney D. Townley.

While engaged in photometric work at the Lick Observatory during the past summer, a few experiments were made to determine the amount of light received from the sky at night when the Moon is not shining. This work was undertaken at the request of Director Campbell, to whom the problem was suggested by Professor Newcomb. This problem is one to which very little attention has been given, but it is nevertheless one of considerable importance, because it has a direct bearing upon the theories of the structure of the universe. The problem of the structure of the universe, after having lain dormant for nearly a century, is now again commanding the attention of investigators.

Both visual and photographic methods are applicable to the determination of the total amount of light received from the sky, and Professor Newcomb has already employed some of the visual methods, the results of which were printed in the *Astrophysical Journal* (December, 1901). The problem may be divided into two parts: first, to determine the relative brightness of different portions of the sky; and second, to determine, in terms of star-brightness, the amount of light received from a unit of sky-surface in one or more regions of the sky. Professor Newcomb's experiments were performed while spending a summer vacation in the country, where he had at his disposal only some very crude pieces of apparatus. Several methods, which I will not stop to describe, were used by him to determine the relative brightness of different portions of the sky, the conclusion being that the illumination of the Galaxy is about twice that of other portions of the sky. To solve the second part of the problem, Professor Newcomb used a concave spectacle-lens to spread out the light of a star, and then compared this image, reduced by means of dark glass, with an equal area of neighboring sky. Various stars were tried, and it was found that with the particular lens and absorbing-glass used the spread-out image of α *Pegasi* was equal in brightness to the neighboring sky. It will perhaps be sufficient to give the results of these observations, without going into the details of the reductions. The result is that a circle of non-galactic sky one degree in diameter gives 0.9 the light of a star of the fifth magnitude.

My efforts were directed almost exclusively to perfecting a photographic method. The results obtained are meager, but it is believed that a reliable method has been found.

As the light of the sky cannot be concentrated at a point, we must, if we wish to get its value in terms of the light of a star of a certain magnitude, take some means to spread out the light of the star. It was at first thought that this might be accomplished by inserting a photographic plate a few inches behind the focus of a photographic telescope. The Crocker telescope (6 inches aperture and 33 inches focus) was first used for this purpose. A rapid plate (Cramer Crown) was exposed for one hour on *Vega,* about 25 centimeters out of focus. An impression 1.9 centimeters in diameter was formed on the plate, but it was found that the light was very unevenly distributed. The impression was made up of small dark granules surrounded by lighter circles. A straight "gash" ran nearly across the center of the circle, and there were also several smaller curved "gashes." A second plate showed exactly the same pattern, which is due, I suppose, to lack of homogeneity in the glass of the lenses. Similar tests with another lens gave somewhat better results, but not sufficiently good for the purpose. This method had therefore to be abandoned.

The next method tried, and the one adopted, is indeed very simple. Both lenses were removed from the Crocker photographic telescope, and several cardboard diaphragms were made so that they could be attached to the end of the telescope-tube. An exposure of one hour was made upon *Vega* with an aperture of three centimeters, and the result was, of course, an impression on the plate of the size and form of the aperture. Exposures were then made upon the sky for equivalent lengths of time, with apertures ranging from 10 to 15 centimeters. The result should be a nearly uniform darkening all over the plate, which would receive light from an area of the sky the diameter of which would depend upon the aperture used and the distance of the plate from the aperture. If the darkening of one of these plates should be of the same intensity as the impression made by the light of *Vega,* then we would have the very simple relation,—the light received from an area of sky x degrees in diameter is equal in actinic intensity to the light received from *Vega*. After a few experiments, it was seen that the time necessary to get a set of plates—about five hours—could be greatly reduced and the effect of changing atmospheric absorption avoided by making all of the exposures on the sky at the same time. This was accomplished by mounting four camera-boxes, simply aperture and plate-holders, upon a polar axis made of a piece of wood 4×4 inches. In the very limited length of time which I had to devote to this work it was possible to obtain only a few sets of plates. All the plates of each set were, of course, developed at the same time in a large tray. In the exposures a portion of each plate was left covered by the slide in order to measure the effect of any chemical fog which might appear in the development. Several regions of the sky were used, and two stars, *Vega* and *Arcturus*. As *Arcturus* is a yellow star, only a very faint impression was obtained with a one-hour exposure; and as extreme development was necessary to bring out anything, the plates are not to be relied upon.

The intensity of the various plates has been measured by means of an excellent Lummer-Brodhun photometer, kindly placed at my disposal by the Department of Physics of the University of California. It seems hardly necessary to go into details of these measurements. Two sets of plates give, I believe, reliable results, but I am looking upon them all as merely experimental, and hope to continue the work next summer. In the first of these sets four simultaneous exposures of an hour were made upon the region of sky about half-way between γ *Pegasi* and β *Ceti*,—that is, about 40° south galactic latitude. The angular apertures used were 5° 28′.6, 6° 36′.9, 7° 16′.4, 8° 2′.6, and *Vega* was the comparison-star. The photometric measurements show the darkening of the film due to the light of *Vega* to be exactly equivalent to the darkening upon the third plate,—that is, the light from an area of rather vacant non-galactic sky 7° 16′.4 in diameter possesses the same actinic intensity as the light of *Vega*. We will have, therefore, taking the magnitude of *Vega* to be 0.2, the light received from an area one degree in diameter equivalent to the light of a 4.5-magnitude star, which is not far from the result obtained by Professor NEWCOMB, using visual methods,—namely, that the light received from a circle of non-galactic sky one degree in diameter is equivalent to 0.9 the light of a star of the fifth magnitude.

In the second set of plates *Vega* was the comparison-star, and the sky used was a portion of the Milky Way nearest *Vega*. The photometric measurement of these plates gives the light of *Vega* equivalent to that received from an area of galactic sky 5° 19′.8 in diameter. From these two sets we find galactic sky 1.9 times brighter than non-galactic sky, which is also in fair accord with the results obtained by Professor NEWCOMB, but does not agree very well with most persons' general impression of the relative brightness of galactic and non-galactic sky.

As before stated, these results are to be taken as provisional only. It is my intention to carry on the work again next summer, and it is believed that valuable results can now be obtained. I wish to express my obligations to Director CAMPBELL, who kindly placed at my disposal all material and equipment necessary to carry out the experiments.

BERKELEY, CAL., 1902, December 24.

PLANETARY PHENOMENA FOR MARCH AND APRIL, 1903.

By MALCOLM MCNEILL.

PHASES OF THE MOON, PACIFIC TIME.

First Quarter,	March	6,	$11^h 14^m$ A.M.	First Quarter,	April	4,	$5^h 51^m$ P.M.
Full Moon,	"	13,	4 13 A.M.	Full Moon,	"	11,	4 18 P.M.
Last Quarter,	"	20,	6 8 P.M.	Last Quarter,	"	19,	1 30 P.M.
New Moon,	"	28,	5 26 P M.	New Moon,	"	27,	5 31 A.M.

The vernal equinox, the time when the Sun crosses the equator from south to north and spring begins, occurs March 21st, 11 A. M., Pacific time.

There will be two eclipses during the period March-April. The first is an annular eclipse of the Sun, on March 28th. The